Project: Leaching evaluation conducted at The Bridges at Rancho Santa Fe

Principal investigators: Mike Hathaway and Nathan Radwick

Cooperators: Larry Stowell and Wendy Gelernter

Summary

A study was designed to quantify the changes in soil chemistry that occur following leaching. Nine greens were leached by applying 5.5 inches of water using the green-side heads and supplemental irrigation heads manually placed on the greens. Nine greens were not leached. The soils of leached and non-leached greens were then tested using three different methods: 1) saturated paste extractions; 2) Mehlich III extractions and 3) were 1:2 soil:water electrical conductivity evaluation. We found, as expected, major benefits associated with leaching which included dramatic drops in salinity, sodium, sulfur and chloride. Specifically, we found that:

- Leaching reduced salinity by 37% using saturated paste extraction (SPE) methods or 26% using 1:2 soil:water electrical conductivity evaluations
- Sodium parts per million was reduced by 30% using SPE and 33% when evaluated using Mehlich III (M3) extraction
- Sulfur was reduced by 46% using SPE and 40% when evaluated using M3 extraction
- Chloride was reduced by 50% using SPE and 52% when evaluated using M3 extraction.

Materials and methods

Leaching and soil analysis: The front 9 greens were leached and the back 9 greens were not leached. All greens were sampled one day after leaching was completed on the front 9. Leaching was carried out by hand placing 4 Hunter PGP heads with red nozzles at about 60 psi per green. Approximately 5.5 gal/minute was applied with a precipitation rate of about 0.52 inches per hour. Sprinklers were operating for 22 hours. In addition, there were five five-minute irrigation cycles with five minute soak periods using the greens heads (25 minutes) in addition to night time 20 minute irrigation cycle. Toro heads with #10 nozzles delivering 7.6 gal/minute on 150 degree partial coverage. Total application volume was 32,832 gallons. With greens averaging 6,000 sq ft, the total application was about 5.5 inches. Table 2 summarizes the the soil chemical analyses for leached and unleached greens.

Water: The water sample was collected from the irrigation lake. The water is a poor quality irrigation water with an EC of 2.2 dS/m or 1414 ppm total dissolved salts. The calcium:sodium ratio is low and is the primary cause of sodium accumulation in soils. No amendment is recommended but topical application of calcium chloride or gypsum have been recommended.

Key soil quality factors – Mehlich III extraction
Values represent the average of 9 samples from leached greens and 9 samples from non-leached greens. Values highlighted in yellow are significantly different (P<0.05)

Parameter	Not Leached	Leached	Percent Difference	P[1]
pH	7.1	7.3	+13	0.00
Organic Matter (OM%)	1.4	1.6	NS	0.22
Sulfur (SO4-S ppm)	78	47	-40	0.00
Phosphorous (P ppm)	340	322	NS	0.17
Calcium (Ca ppm)	1215	1110	NS	0.09
Magnesium (Mg ppm)	269	249	NS	0.08
Potassium (K ppm)	79	61	-22	0.04
Sodium (Na ppm)	209	141	-33	0.00
Calcium percentage	62	64	NS	0.06
Magnesium percentage	23	24	NS	0.06
Potassium percentage	2.0	1.8	NS	0.16
Sodium percentage	9.2	7.1	-23	0.00
Electrical Conductivity (EC dS/m)	1.9	1.4	-26	0.00
Chloride (Cl ppm)	343	164	-52	0.00
Boron (B ppm)	0.8	0.8	NS	0.88
Iron (Fe ppm)	259	251	NS	0.55
Manganese (Mn ppm)	44	41	NS	0.18
Copper (Cu ppm)	1.9	2.1	NS	0.37
Zinc (Zn ppm)	54	59	NS	0.26
Ammonium nitrogen (NH4 ppm)	2.4	2.4	NS	0.62
Nitrate nitrogen (NO3 ppm)	0.7	0.7	NS	0.62
Total nitrogen (TOTN ppm)	3.1	3.1	NS	0.81

[1]P = Fisher's Protected LSD probability that the values are the same

Key soil quality factors – saturated paste extraction.
Values highlighted in yellow are significantly different (P<0.05). Values represent the average of samples analyzed

Parameter	Not Leaching	Leached	Pecent Difference	P[1]
pH	7.1	7.2	+1.4	0.02
Salts (ppm)	1243	789	-37	0.00
Chloride (Cl ppm)	516	256	-50	0.00
Nitrate (NO3 ppm)	0.06	0.10	NS	0.45
Ammonium (NH4 ppm)	6.8	5.9	-13	0.02
Bicarbonate (HCO3 ppm)	127	158	+24	0.01
Sulfur (S ppm)	83	45	-46	0.00
Phosphorus (P ppm)	13	13	NS	0.57
Calcium (Ca ppm)	101	62	-39	0.00
Calcium (Ca meq)	5.1	3.1	-39	0.00
Calcium (Ca %)	26	25	-4	0.00
Magnesium (Mg ppm)	62	37	-40	0.00
Magnesium (Mg meq)	5.1	3.1	-39	0.00
Magnesium (Mg %)	27	25	-7.4	0.00
Potassium (K ppm)	31	20	-35	0.00
Potassium (K meq)	0.80	0.52	-35	0.00
Potassium (%)	4.2	4.2	NS	0.84
Sodium (Na ppm)	186	130	-30	0.00
Sodium (Na meq)	8.1	5.6	-31	0.00
Sodium (Na %)	43	46	+7	0.00
Total (meq)	19	12	-37	0.00
Broon (B ppm)	0.32	0.28	-13	0.05
Iron (Fe ppm)	0.74	0.75	NS	0.91
Manganese (Mn ppm)	0.54	0.28	-48	0.00
Copper (Cu ppm)	0.04	0.05	NS	0.75
Zinc (An ppm)	0.17	0.14	-18	0.00
Aluminum (Al ppm)	1.2	1.1	NS	0.54
ESP (estimated)	3.9	3.4	-13	0.00
SAR (estimated)	3.6	3.2	-11	0.00

[1]P = Fisher's Protected LSD probability that the values are the same

The Bridges at Rancho Santa Fe

07042301

l lake Lab No: 929 4/17/2007

pH	7.70		
Hardness ppm	612.28		
Electrical Conductivity (dS/m, mmhos/cm)	2.21	TDS (ppm)	1414.4
Sodium Adsorption Ratio (SAR)	4.16		
Adjusted SAR (Adj.SAR)	8.58		
pHc	7.34		
Residual Sodium Carbonate (RSC)	0.00		

Cations	**ppm**	**meq/l**	**lbs/acre ft**
Calcium Ca	122.75	6.13	334.10
Magnesium Mg	74.01	6.09	201.44
Potassium K	4.77	0.12	12.98
Sodium Na	236.28	10.28	643.11
Iron Fe	0.64		1.74
Anions	**ppm**	**meq/l**	**lbs/acre ft**
Total Alkalinity	176.90		
Carbonate CO3	0.00	0.00	0.00
Bicarbonate HCO3	215.85	3.54	587.51
Hydroxide OH	0.00		
Chloride Cl	493.60	13.92	1343.49
Sulfur as SO4	240.93	5.02	655.77
Minors	**ppm**		**lbs/acre ft**
Boron B	0.26		0.71
Manganese Mn	0.11		0.29
Copper Cu	0.04		
Zinc Zn	0.36		
Aluminum Al	0.44		
Nutrients	**ppm**		**lbs/acre ft**
NO2-N			
NO3-N	0		0.00
NH3-N	0.15		0.41
Total P	0.81		2.20

Acid injection is frequently used to amend waters that are high in carbonates and bicarbonates. However, acid amendment is only recommended when carbonates and bicarbonates together comprise more than 50% of the total anions, the RSC is greater than 1.25, and ideally when the water EC is less than 0.5 dS/m.

Reported Carbonates and bicarbonates as a percent of the total anions	23
Estimated pounds of H2SO4 needed per acre ft of water to neutralize CO3 and HCO3	471
Estimated Gallons of H2SO4 needed per acre ft of water to neutralize CO3 and HCO3	31

Gypsum injection is an alternative method of amending water to deliver additional calcium to soils when water EC is less than 1.2 dS/m. In this case, the target is two times more calcium than sodium or magnesium (a 2:1 ratio) measured in milliequivalents per liter (meq/l).

Reported Calcium:sodium ratio in meq/l	0.60
Pounds of gypsum per acre ft of water to deliver 2:1 Ca:Na ratio	3377
Reported Calcium:magnesium ratio in meq/l	1.01
Pounds of gypsum per acre ft of water to deliver 2:1 Ca:Mg ratio	1417

In addition to waters that require modification to balance the cations or for removal of carbonates, some waters have a low EC and moderate SAR that requires amendment to increase the EC of the water to improve water infiltration. Gypsum injection has been the product of choice for this amendment because it increases the EC and drops the SAR at the same

Pounds of gypsum needed per acre foot of water to balance the EC/SAR relationship. If the value is zero, no gypsum is needed.	0

Note: Values reported as 0 (zero) indicate that the element is present below minimum levels of detection. Minimum detection levels for selected elements and compounds are listed below in parts per million (ppm):
NO2 < 0.01; NO3 < 0.10; NH4 < 0.10; Al <0.20; Cu <0.02; Fe <0.10; Zn <0.04, K<0.60